Can the Universe be completely digitized?

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Abstract: The well-known physicist John Archibald Wheeler coined the phrase: It from bit. It symbolizes the idea that our physical universe is information-theoretic in origin. According to this idea our universe can be completely digitized. Proponents of digital physics are thus convinced that the very heart of our universe is of discrete nature. In this paper an argument is presented, which shows that our universe is fundamentally of analogous nature.

The Ur-Theory – A radical atomism

In 1980 the theoretical physicist Carl Friedrich von Weizsäcker published his theory of ur-alternatives which was a kind of digital physics. It based essentially on the thesis: *Energy is information.*

This thesis was obtained by a series of purely philosophical considerations about the Aristotelian relationship of substance and form. It started with concrete things of our everyday world like a cupboard. If we look at such an ordinary object like a cupboard, we will find, that in the realm of concrete physical things, no form exists without matter. Nor can there be matter without form. In this specific case the cupboard is made of wood. Wood is its matter. The name of the term matter is in fact taken from this example: *materia* = *hyle*, which means wood. But the cupboard isn't simply wood, it is a wooden cupboard. Cupboard is what it is intrinsically; cupboard is its *eidos,* its form. But a cupboard must be made of something; a cupboard without matter is a mere thought abstracted from reality. On the contrary, this cupboard made of wood is a real whole of form and matter. Von Weizsäcker called such a real thing like the cupboard a *synholon*. He concluded: In all real things form and matter are grown together.

Taking this everyday example von Weizsäcker goes on to the doctrine of atomism. According to this doctrine there exists a first matter, in which the conception matter is no longer a relative term in the relation matter-form. Instead of that it designates what truly exists in itself.

In the nineteenth century, a new term paired with matter arose - namely, energy which was recognized as the capacity for moving matter. This capacity finally turned into substance as a result of the first law of thermodynamics - the law of the conservation of energy.

Energy could be quantitatively measured, and it turns out that its quantity, just like the quantity of matter, was conserved in time. Energy was therefore regarded as a substrate that remained unchanged in the world of changing appearances.

Albert Einstein finally recognized energy and mass were relativistically equivalent. As all forms of energy were comparable among, they could at least in principle be transformed into one another. Therefore it was tried to develop a universal equation in which the elementary particles could be derived as different quasi-stationary states or forms of energy. Heisenberg's unified field theory constituted an attempt in this direction.[1]

Von Weizsäcker followed this approach, which should lead him to a view, called by himself "radical atomism". To realize this view he investigated the term of information – looking for the most elementary form that can be really there. He states, that information can be defined as the quantity of form.

"Let E be a formally possible event, and p its probability. Then

$$I = -\log_2 p$$

is the information obtained when E occurs. If, for example, $p = ½$, then $I = 1$ or, as one says, 1 bit; if $p = (½)^n$, then $I = n$. The less probable an event is, the more information it furnishes." [2]

According to von Weizsäcker the information of an event could be defined as the number of completely undecided binary alternatives that are decided by the occurrence of the event. A simple binary alternative is said to be completely undecided if neither one of its two possible answers is more probable than the other. One can define the quantitative measure of the form of an object as the number of simple alternatives that must be decided in order to describe this form. In this sense, the information contained in an object measures exactly its amount of form. Consequently he concluded: "Information measures form."

After his journey through the world of information theory von Weizsäckers tried to precise the meaning of the first matter in an axiomatic manner.

He makes clear, that first matter cannot be characterized other than in terms of the form one can find in it. What characterizes it as matter in this sentence is the "can": matter is the possibility of form. The "in it" in the sentence is therefore a pleonasm: first matter is not a something "in which" a form can be found; this would be true only if it were a form still different somehow from the form "in it". Rather, it *is* the possibility of finding form. What can be found is *eo ipse* form.

Whether a particular form is or is not there constitutes therefore a binary alternative. To distinguish among many different forms we must decide a multiplicity of such simple binary alternatives. Wherever a particular form is found empirically, a number of simple binary alternatives are being decided empirically.

Formulated as a very basic hypothesis it can be said: All forms are built up by a combination or composition of such simple binary alternatives. In other words, the bit is the simplest form that energy or "it" can take.

Von Weizsäcker considered this kind of digital physics as a *radical atomism* based on the notion of logical instead of spatial divisibility. It answered one of the most important questions of the physics of elementary particles: Is there a limit to divisibility?

If objects, thus also particles, are reduced to bits then an ultimate limit of divisibility is reached, because a bit includes the most minimal amount of form a real thing can have. [2]

Usually this radical atomism is called the “ur-theory”. It is a program to understand the unity of physics. [3]

But von Weizsäcker left the most important question unanswered: Can our universe be composed of such real bits at all?

Nernst meets Zuse

If we want to speak about a bit as a real thing, then energy and information must be inseparably mixed together. But if we assume that a bit is a real thing it can have only two possible states, like a photon that can be in two different spin states, i.e., up or down..

But in the case of real bits, which we can call “bitoms”, a specific and very far-reaching restriction is involved: Their two possible states whatever they may be do have exactly the same probability, that is, 50 : 50, or: $p = ½$. Hence, in a universe which would be composed of such “bitoms” nothing would happen. This universe would be in an unchanging everlasting state like a huge perfect crystal lattice.

In our physics such a state is already described by the third law of thermodynamics. This law implies that the entropy of a substance approaches zero as the absolute temperature approaches zero. It actually happens in the case of perfectly crystalline solids.

If we turn around this physical law which is in good agreement with the experimental results assuming that this perfect crystal would be fundamentally composed of bitoms, then our universe would be really a cold machine in the truest sense of the word: its temperature would be zero: $T = 0$.

But measurements of the cosmic microwave background radiation have shown that the temperature of our universe is not zero, it is: $T = 2.735$ degrees above zero. This measurement can be taken as a sort of proof that our universe is not of digital but of analogous character. It signals clearly that our universe is not a cold machine, but it is a warm being – even at the most fundamental level.

References:

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[2] Carl Friedrich von Weizsäcker, *The Unity of Nature*, Farrar, Straus & Giroux Inc., 1980
[3] Carl Friedrich von Weizsäcker, *The Structure of Physics*, Springer Netherlands, 2006
[4] Holger Lyre, *Multiple Quantization and the Concept of Information*, International Journal of Theoretical Physics, Vol. 35, No. 11, p. 2219 - 2225, 1996